MULE DEER PASSAGE BENEATH AN OVERLAND COAL CONVEYER

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Abstract.— Presently, information pertaining to migration and daily movement patterns of big game in relation to overland conveyors or large diameter pipelines is sparse. A literature review showed that moose (*Alces alces*), caribou (*Rangifer tarandus granti*), reindeer, and dall sheep (*Ovis dalli dalli*) will pass beneath or over large diameter pipeline systems. But no information was found relative to big game crossing coal conveyor systems. Mule deer (*Odocoileus hemionus*) passage beneath an overland coal conveyor in Carbon County, Utah, was studied during spring 1981. Deer avoided crossing at underpass opportunities where the clearance was less than 50 cm. Clearances between 50 and 90 cm were selected for crossing. Deer passed beneath the conveyor during day and nighttime conditions and while the conveyor was either operating or idle. Recommendations are discussed for designing conveyors and pipelines to facilitate big game passage.

Wildlife agencies are presently faced with assessing the impacts of diverse development on wildlife. They are frequently forced to perform such assessments without the benefit of substantial information or guidelines. One area of particular concern to the Utah Division of Wildlife Resources is the creation of barriers to big game migration. This paper will focus on barriers such as overland conveyor systems and large-diameter aboveground pipelines. Typically, without adequate precautions, these structures cannot be crossed by big game animals. Increased industrial use of these structures has prompted the need for understanding the impacts of big game movement. Transportation of water, gases, minerals, and other products over long distances by use of overland conveyors, slurry lines, or large-diameter pipelines is a historic practice. The economic feasibility of such has been enhanced by escalating fuel costs and prospects of using saline water in slurry lines. These structures can create migration as well as daily movement problems for big game.

A review of pertinent literature and surveys of other wildlife agencies in the West indicate that the Trans-Alaska Pipeline is the only similar structure that has been studied relative to big game movement. Child (1973) assessed the reactions of caribou to various aboveground designs of simulated pipelines in Prudhoe Bay, Alaska. Most caribou (78%) approaching the simulation either reversed their direction of movement or circumvented the structure. When crossings were made, overpass ramps were utilized three times more often than underpasses. Avoidance of the Trans-Alaska Pipeline during migration, and abandonment of most calving in the Prudhoe Bay area continue to be a problem (Cameron et al. 1979, Cameron and Whitten 1982). Child and Lent (1973) found the responses of semidomesticated reindeer to be similar to that of caribou.

Van Ballenberghe (1978) evaluated the reaction of moose to the Trans-Alaska Pipeline. Moose rarely moved over pipeline sections that had recently been buried. Most moose crossings were beneath pipeline sections elevated 1.8 m or more. Hinman (1974) noted that moose along the Davidson Ditch Pipeline near Fairbanks, Alaska, would not cross at clearances less than 1.5 m.

Dall sheep in Alaska are known to cross beneath pipelines providing 1.5 m clearance during migration (W. Smith, pers. comm., Alaska Department of Fish and Game).

In an effort to understand the effects of an overland coal conveyor on mule deer migration and daily movements in Utah, a recently constructed conveyor was studied.

Study Site

The overland coal conveyor is in Wattis Canyon, Carbon County, Utah (39°31′ N

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Lat., 111°02′ W Long.), and is operated by Plateau Mining Company's Star Point Mine. Wattis Canyon is on the east side of the Wasatch Plateau, and drains from west to east. The canyon sides are steep and support a mountain brush vegetative type. Scattered stands of Douglas fir (*Pseudotsuga menziesii*) are located in the drainages of the north-facing slope. Predominant vegetation at the mouth of the canyon consists of pinyon pine (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*) interspersed with sagebrush (*Artemisia tridentata* and *A. nova*). The conveyor system is situated near the base of the north-facing slope.

Most deer use of this area occurs during fall and spring migration, although a few deer remain yearlong. Alignment of the conveyor is such that it generally parallels the drainage as well as the direction of spring and fall deer migrations. The conveyor extends downslope 1.4 km from the edge of deer summer range into winter range. The conveyor structure is 1.8 m wide, covered by corrugated metal with vertical leg supports spaced 6.1 m apart. It emits a constant noise while operating that measures 77 decibels (comparable to an idling vehicle) at a distance of 1 m.

Methods

Between 10 April and 4 May 1981, 9 inspections of Plateau's conveyor were conducted to document evidence of tracks or direct observation of deer crossing beneath the conveyor. The winter and spring of 1981 was comparatively dry, with little snow accumulation. No snow was present during the study period. Two short sections of the conveyor were not monitored: the tipple (discharge) end at the terminus of the conveyor, which provided clearances greater than 3 m; and the portal end, which was positioned next to the ground, thus allowing no clearance. Passage opportunity greater than 3 m was assumed (based on field observation of deer at another conveyor structure) to not interfere with movement.

In addition, 149 random measurements were taken along the monitored length of the conveyor to estimate statistics relative to clearance beneath it. Correlation analysis, chi-square analysis, and Bonferroni normal statistics (Neu et al. 1974) were used to quantitatively analyze the data.

Results and Discussion

During the study period, 150 mule deer crossings under the conveyor were documented. Surveys to determine the presence of deer migration trails revealed numerous routes adjacent to the conveyor. Most trails paralleled the structure. The few that bisected it were usually obliterated by construction activity. The mean clearance and standard error (SE) beneath the conveyor for observed deer crossings was 70.8 (1.3) cm. Random measurements along the conveyor showed the mean clearance to be 67.8 (3.5) cm. Correlation analysis of clearance categories 30 cm or greater showed a significant correlation between the actual deer crossings and random measurements ($r = 0.81$, $P < 0.001$). This would appear to indicate that the proportion (availability) of the various clearances along the conveyor determined the amount of deer use in each clearance category (Table 1).

However, further evaluation through chi-square analysis (goodness-of-fit test) showed a significant difference between the observed and expected number of deer crossings for the various clearance categories ($\chi^2 = 78.5$, 6 d.f., $P < 0.0005$). Thus the hypothesis that the number of deer crossings within each clearance category was proportional to the availability of each clearance category was rejected. Next, the analysis technique developed by Neu et al. (1974) was used to determine which clearance categories were avoided and which were preferred for crossings. Comparisons of the expected proportion of deer crossings in each clearance category, to the 99% confidence interval on observed proportions of deer crossings, were made. Deer crossed at clearances of 50 to 90 cm significantly more than expected; 88% of the deer crossings were made within this range of clearances, although only 56% of the crossings were expected. Clearances of 90 to 130 cm were used in proportion to their availability; 9% of the deer crossings were observed in this range of clearances, and 7% were expected. The two remaining clearance categories, 0 to 50 cm and 130 to 150 cm, were used significantly less than expected: 3% of the deer crossings were observed, but 32% were expected in the lowest category, and 1% of the deer crossings were observed in the highest category when 5% was expected (Tables 1 and 2).

Undoubtedly, clearances less than 50 cm were avoided. This is partly explained because of the difficulty for most mule deer to physically squeeze beneath structures providing less than 30 cm clearance. However, Falk et al. (1978) have documented white-tailed deer (*Odocoileus virginianus*) to crawl under highway fences where gaps of only 23 cm existed. For the lowest crossing documented beneath the conveyor (33 cm), drag marks and hair were left by the mule deer. Also, during times of conveyor operation it is speculated that the presence of a moving belt, and it possibly rubbing the deer's back, would hinder crossing at such low clearances.

Clearances from 50 to 130 cm were readily used by deer (the range of heights from 50 to 90 cm appeared to be preferred), but clearances greater than 130 cm seemed to be avoided. It is our opinion that once suitable clearance was provided (50 cm) and all other circumstances were acceptable, a crossing was made. The apparent preference by deer for heights ranging from 50 to 90 cm is most likely explained by the high availability (56%) of crossing opportunities along the conveyor in this category. What seems to be avoidance, from a statistical perspective, of the 130 cm or greater heights is misleading. It may simply reflect the presence of human activity near those portions of the conveyor (the tipple-loadout area), or the high likelihood that deer would encounter suitable crossing opportunity first (only 5% of the crossing opportunities were of heights greater than 130 cm).

Behavioral observations of 22 deer-conveyor interactions were made. No deer attempted to jump over the structure. Deer passed beneath the conveyor at times when it was in operation as well as when it was idle. Deer did pass during both day and night conditions. Some deer showed signs of anxiety when near the conveyor, but others gave no indication of concern. A few deer refused to cross even though highly motivated and sought alternate routes.

In Alaska, Child (1973) reported that small groups of caribou were more apt to cross the simulated pipeline than large groups. Adult bulls of mixed herds usually went around the simulated pipeline. Nursery bands or groups under female leadership investigated and made the most use of crossing structures. Crossing of the simulated pipeline often resulted in splitting of herd groups, and in some cases separated cows from calves for up to two hours. Hinman (1974) noted that moose in Alaska always made a crossing, when suitable opportunities were provided, within 800 m of the point where the animal first encountered the pipeline. Use of crossing structures was also highly correlated with the level of insect harassment.

Table 1. Number of mule deer passages and random measurements per clearance category, Plateau Mining Company's overland coal conveyor, Carbon County, Utah, 1981.

Clearance categories (cm)	Number of deer passages	Number of random measurements	Clearance categories (cm)	Number of deer passages	Number of random measurements
0–30	0	21	90–95	2	3
30–35	1	8	95–100	2	3
35–40	0	5	100–105	1	1
40–45	1	4	105–110	5	1
45–50	2	10	110–115	1	0
50–55	9	11	115–120	0	0
55–60	25	12	120–125	1	3
60–65	21	15	125–130	1	0
65–70	23	16	130–135	0	1
70–75	25	17	135–140	0	0
75–80	17	5	140–145	1	0
80–85	5	5	145–150+	0	6
85–90	7	2			

RECOMMENDATIONS

Unfortunately, with the limited amount of information relative to big game passage under or over barriers, much speculation is involved in making recommendations at this time.

When planning and designing an overland conveyor system or similar structure, there are several important considerations. The known or projected response of big game to the structure must be considered. This not only includes big game already present, but also species that could potentially inhabit the area. Thus far, researchers have measured varying responses by big game to barrier structures. Experience from the Trans-Alaska Pipeline and similar barriers indicates that moose will cross under a structure elevated to allow at least 1.5 to 1.8 m of clearance with minimal accumulation of snow (Van Ballenberghe 1977, Hinman 1974). Caribou are much more sensitive and prefer to avoid structures. During times of stress (migration and insect harassment) they sometimes attempted to cross, preferring to use overpasses (Child 1973, Cameron et al. 1979, Cameron and Whitten 1982). No information was found on elk (*Cervus elaphus*), but we suspect that elk response to a barrier structure would be similar to that of caribou.

Site-specific factors must also be considered. Design of crossing structures must take into account snow accumulation and vegetation growth beneath the structure, which could effectively reduce the passage clearance during certain seasons. Topography of the area should be considered in the design. Canyons and washes provide natural locations for underpass opportunities, and cutbanks through hillsides and ridges can be developed into overpass structures.

Overland coal conveyors must have either a sufficient number of strategically placed passage structures to allow big game movement, or be adequately elevated along at least 60% to 70% of the total conveyor. The first option requires site-specific studies relative to big game migration and daily movement patterns.

Construction of underpass opportunities demands the greatest attention to individual species requirements. Mule deer use highway underpasses with varying degrees of success (Reed et al. 1975, Reed 1981, Ward 1978). These highway underpasses were typically 3.05 m wide and 3.05 m high. In central Utah, deer use underpasses along Interstate 15 for both daily movements and migration (Smith and Greenwood 1983). Our study suggests that underpass structures along conveyors require a minimum clearance of 1.0 m for use by mule deer and other species similar in stature, such as pronghorn antelope (*Antilocapra americana*) and bighorn sheep (*Ovis canadensis*). A minimum clearance of 3.0 m is recommended for moose and elk. These recommendations allow for snow accumulation and vegetation growth under the structure. The width for underpass opportunities will most likely be determined by the support structures required to meet engineering specifications, but should be as wide as possible. Vertical support structures are

TABLE 2. Observed and expected frequencies of mule deer crossing under Plateau Mining Company's overland coal conveyor, Carbon County, Utah, 10 April–4 May 1981.

Clearance categories (cm)	Observed		Expected[a]		99% confidence interval on Pi[b]	Selection behavior[c]
	N	Proportion (Pi)	N	Proportion		
0 to 30	0	0.0	21	0.141	—[d]	avoided
30 to 50	4	0.027	27	0.181	0.015–0.069	avoided
50 to 70	78	0.520	54	0.362	0.390–0.650	preferred
70 to 90	54	0.360	29	0.195	0.235–0.485	preferred
90 to 110	10	0.067	8	0.054	0.002–0.132	indifferent
110 to 130	3	0.020	3	0.020	0.016–0.056	indifferent
130 to 150+	1	0.007	7	0.047	0.015–0.029	avoided
Total	150		149			

[a]Derived from random measurements.
[b]From Neu et al. (1974).
[c]Clearances avoided were used significantly less than expected; clearances preferred used significantly more; clearances indifferent used as expected.
[d]No confidence interval on O observation.

located every 18.3 m along the Trans-Alaska Pipeline (Van Ballenburghe 1978). Plateau's coal conveyor provides a width of 6.1 m between support structures. A minimum width of 6 m is recommended for deer and similar big game, and 18 m for moose and elk.

Information relative to an overpass structure is limited. Bridges are sometimes constructed across canals to provide a crossing opportunity for big game; Latham and Verzuh (1971) recommend these bridges to be at least 2.4 m wide with 10 cm of soil on top. Child (1973) constructed ramps over the simulated barrier that were approximately 30 m wide and long with 2:1 or 5:1 (horizontal to vertical) side-slopes fanning out 360 degrees from the barrier. Along the Trans-Alaska Pipeline overpasses are constructed as mounds 9 m wide (W. Smith, pers. comm.).

Based on this information, it is recommended that overpass structures be designed as circular earthen ramps bisected by the conveyor. The round shape should not repel animals that are foraging or moving along the barrier, and would encourage animals approaching from any direction to move up and over the barrier. Each half of the ramp should provide a travel path with side-slopes no greater than 60% from horizontal. The two halves should be connected by a 10-m wide platform spanning the barrier. However, burying a conveyor for a distance of at least 15 m would be a better alternative than constructing overpasses. Buried segments of the Trans-Alaska Pipeline 15 to 25 m in length are most acceptable to caribou (W. Smith, pers. comm.).

Additional planning and design of passage structures should include providing a safe travel-way to move big game up to and beyond barriers. Consideration should be given to development of mature trees and an abundance of browse and grass-forb communities along and approaching the barrier and at crossing opportunities.

In this study on deer, evaluation of behavior was limited. No determination of the number of deer deflected by the conveyor was made. This study simply documents the clearance heights of a barrier under which some deer will pass. Only through continued research on mule deer and other big game will the full impact of such barriers be understood, and additional mitigation techniques developed.

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Literature Cited

Child, K. N. 1973. The reactions of barren-ground caribou (*Rangifer tarandus granti*) to simulated pipeline and pipeline crossing structures at Prudhoe Bay, Alaska. Compl. Rep. Alaska Coop. Wildl. Res. Unit, Univ. of Alaska, Fairbanks. 51 pp.

Child, K. N., and P. C. Lent. 1973. The reactions of reindeer to a pipeline simulation at Penny River, Alaska. Interim Rep., Alaska Coop. Wildl. Res. Unit, Univ. of Alaska, Fairbanks. 29 pp.

Cameron, R. D., and K. R. Whitten. 1982. Effects of the Trans-Alaska Pipeline on caribou movements. Alaska Department of Fish and Game. Fed. Aid Wildl. Rest. Proj. W-21-1 and W-21-2, Job No. 3.18R. 25 pp.

Cameron, R. D., K. R. Whitten, W. T. Smith, and D. D. Roby. 1979. Caribou distribution and group composition associated with construction of the Trans-Alaska Pipeline. Can. Field-Natur. 93:155–162.

Falk, N. W., H. B. Graves, and E. D. Bellis. 1978. Highway right-of-way fences as deer deterrents. J. Wildl. Manage. 42:646–650.

Hinman, R. 1974. The impact of oil development on wildlife populations in northern Alaska. Pages 156–164 *in* Proc. 54th Ann. Conf. of West. Assoc. State Game and Fish Comm. Albuquerque, New Mexico.

Latham, H. S., and J. M. Verzuh. 1971. Reducing hazards to people and animals of reclamation canals. U.S. Bur. Reclamation Rep. No. REC-ERC-71-36. 30 pp.

Neu, C. W., C. R. Byers, and J. M. Peek. 1974. A technique for analysis of utilization-availability data. J. Wildl. Manage. 38:541–545.

Reed, D. F., T. N. Woodard, and T. M. Pojar. 1975. Behavioral response of mule deer to a highway underpass. J. Wildl. Manage. 39:361–367.

Reed, D. F. 1981. Mule deer behavior at a highway underpass exit. J. Wildl. Manage. 45:542–543.

Smith, R. B., and C. L. Greenwood. 1983. Big game use along the proposed Mona-Nephi-Sevier Canal alignments, irrigation and drainage system, Bonneville Unit, Central Utah Project. Utah Div. Wildl. Resour. prep. for U.S. Dep. Inter. Bur. of Reclamation. 82 pp.

Van Ballenberghe, V. 1978. Final report on the effects of the Trans-Alaska Pipeline on moose movements. Joint State/Fed. Fish and Wildl. Adv. Team, Spec. Rep. No. 23, Anchorage. 41 pp.

Ward, A. L. 1978. The effects of highway operation practices and facilities on elk, mule deer, and pronghorn antelope. Ann. Rept., Proj. No. 942-41-42-13-0088-33F2-6-2580, cont. Fed. Highway Adm. Rep. No. FHWA-RD-76-174.